


# Market Access and Intermediate Goods Trade

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July 2009

**Abstract**

The role of importer access to the finished goods market in intermediate goods trade is examined by estimating the gravity-like equation derived from the NEG model. Importer access to demand for finished goods is calculated by using the estimates in the gravity equation for finished goods trade, and then intermediate goods trade is regressed on the importer access. Results indicate that imports of intermediate goods are sensitive not only to the magnitude of importer demand for finished goods but also to the demand of neighboring countries. Using results of the regression, the impact of US finished goods market expansion on intermediate goods trade in each country is simulated.

**Keywords:** Gravity; Intermediate Goods Trade; OECD

**JEL classification:** F12; F14; R12

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# Market Access and Intermediate Goods Trade

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**Abstract:** The role of importer access to the finished goods market in intermediate goods trade is examined by estimating the gravity-like equation derived from the NEG model. Importer access to demand for finished goods is calculated by using the estimates in the gravity equation for finished goods trade, and then intermediate goods trade is regressed on the importer access. Results indicate that imports of intermediate goods are sensitive not only to the magnitude of importer demand for finished goods but also to the demand of neighboring countries. Using results of the regression, the impact of US finished goods market expansion on intermediate goods trade in each country is simulated.

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## 1. Introduction

That a gravity equation is one of the most valuable tools for quantitatively analyzing bilateral trade patterns successfully is well known. A traditional gravity equation has a log of bilateral trade as a dependent variable, and logs of importer and exporter GDP's as well as a log of distance between trading partners function as independent variables. Derived estimations generally always provide excellent empirical fit. Relying on such properties, a large number of scholars have employed gravity equations in their investigations of bilateral trade. A gravity equation has been used to clarify the causes of growth in world trade after the Second World War (Baier and Bergstrand, 2001). The impact of international agreements on trade such as the Free Trade Agreement (FTA), or those of international organizations like the World Trade Organization have also been evaluated using a gravity equation (Baier and Bergstrand, 2007; Rose, 2004).

Based on the rapid growth of intermediate goods trade, it is becoming even more important to clarify the mechanics of such trade. Worldwide trade in machinery parts and components has grown from \$336 billion in 1987 to \$1,299 billion in 2003. Commodity trade has increased from \$2,127 billion to \$6,526 billion, and trade in machinery goods has gone from \$837 billion to \$2,913 billion (Kimura *et al*, 2007). As a result, the share of machinery parts and components in total commodity trade has increased from 16% to 20%, and machinery goods trade has grown from 40% to 45%. Yi (2003) indicates that trade in intermediate goods seems to follow different mechanics from those of trade in finished goods. Thus, empirical methods for analyzing these two types of goods may also be different. Although there are now a variety of theoretical models supporting gravity formulation (for example Combes *et al*, 2008, p. 127), a traditional gravity equation is not necessarily suited for analysis of intermediate goods trade.

Specifically, a traditional gravity equation fails to capture the distinctive features of intermediate goods trade. It can only clarify the role of importer demand for finished goods in this trade.<sup>1</sup> Domestic producers of finished goods do not necessarily import intermediate goods in order to supply their assembled products only to the domestic market. For example, intermediate goods in Mexico seem to be imported for assembly into finished goods, and these assembled finished goods are then exported to the US.

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<sup>1</sup> Some researchers have applied a basically traditional gravity equation only to the intermediate goods trade (for example Athukorala and Yamashita, 2006; Kimura *et al*, 2007). Such research indicates that gravity also works in the intermediate goods trade as follows: High importer and exporter GDP's encourage active intermediate goods trade, but long distances between them discourages it.

Further, some Eastern European countries may import intermediate goods from Japan in order to export finished goods to Western European countries. As a result, imports of intermediate goods may be sensitive not only to the magnitude of importer demand for finished goods but also to the demand of neighboring countries. Since a traditional gravity equation includes only the demand of the importing country and not the demand of its neighboring countries, it has remained unknown whether or not importer access to such demand for finished goods is important for intermediate goods trade.

Given the above discussion, the role of importer access to demand for finished goods in intermediate goods trade is examined in this paper by estimating gravity equations for trade in upstream and downstream products separately. These equations are derived from the new economic geography (NEG) model which was developed through the pioneering work of Krugman (1991). The fundamental goal of this research is to estimate a gravity equation for trade in upstream products. This includes importer demand for upstream products, which depends not only on importer demand for downstream products but also the demand of neighboring countries adjusted by trade costs with the importer. Such importer demand for downstream products may be obtained by using the Redding and Venables (2004) method. Using regression techniques, a gravity equation for trade in downstream products is developed to obtain estimates of importer-fixed effects and parameters of a trade cost function. Using these estimates, each country's access to the demand for downstream products could be determined and then regressed on bilateral trade in upstream products.

This research contributes not only to literature on gravity but also to empirical studies of the NEG. In the gravity literature, it includes careful exploration of the mechanics of intermediate goods trade. Based on the model developed here, the impact of a rise of total income in a given country on intermediate goods trade, taking input-output relationships and trade costs into account, can be investigated. In empirical investigation of the NEG, on the other hand, this research extends the application range of the Redding and Venables method. Price index is a key variable in the NEG. However, it is hard to obtain its data or to control its effects. Consequently, a two-step approach proposed by Redding and Venables has been adopted in the literature.<sup>2</sup> Estimates obtained initially in a gravity equation are used for constructing market access measures. Their relationships with economic variables can then be examined. Redding and Venables (2004) as well as other researchers (Head and Mayer, 2006; Knaap, 2006; Redding and Schott, 2003) have used such an approach to examine the relationship between wages and market access. Head and Mayer (2004) used such

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<sup>2</sup> For other methods of controlling the price index, see Combes *et al* (2008, Section 5.1.4).

an approach in the context of location choice analysis. The present research examines the relationship between intermediate goods trade and market access constructed by using estimates of a gravity equation for finished goods trade.

The paper is organized as follows: A theoretical framework underlying gravity equations used in this research is provided in Section 2. The empirical strategy for estimating the equations is explained in Section 3, and regression results are reported in Section 4. Concluding remarks are given in Section 5.

## 2. Theoretical Framework

A representative consumer in each region is assumed to have a two tier utility function. The upper tier is a Cobb-Douglas function of the utility derived from consumption of downstream goods (finished goods). Specifically, the following utility function of the consumer in region  $r$  is applied:

$$U_r = \prod_i (C_r^i)^{\alpha_i}, \quad \sum_i \alpha_i = 1,$$

where  $C_r^i$  is the aggregate consumption of a downstream good  $i$  in country  $r$ .

Consider expenditure allocation in a downstream good  $i$  consisting of multiple varieties differentiated by country (the Armington assumption) with the subscript representing the name of downstream goods omitted for now. A consumer has the following preference specified as a constant elasticity of substitution (CES) function over varieties:

$$C_r = \left( \sum_{s=1}^R X_{sr} \frac{\sigma-1}{\sigma} \right)^{\frac{\sigma}{\sigma-1}},$$

where  $R$  and  $X_{sr}$  are respectively the number of countries and the demand of country  $r$  for the downstream variety produced in country  $s$ .  $\sigma$  is the elasticity of substitution between downstream varieties and is assumed to be greater than unity. The utility maximization yields:

$$X_{sr} = \alpha \tau_{sr}^{-(\sigma-1)} p_s^{-\sigma} P_r^{\sigma-1} Y_r, \quad (1)$$

where  $p_s$  and  $P_r$  denote respectively the price of the downstream variety produced in country  $s$  and the price index of downstream goods in country  $r$ .  $Y_r$  is total expenditure/income in country  $r$ . Transactions in downstream goods between countries  $r$  and  $s$  may be modeled as facing Samuelsonian iceberg costs,  $\tau_{sr} (\geq 1)$ . As a result, the total production value of downstream industry in country  $i$ , which is denoted by  $E_i$ , is

given by:

$$\begin{aligned}
E_i &\equiv p_i X_i \\
&= p_i \sum_r \alpha \tau_{ir}^{-(\sigma-1)} p_i^{-\sigma} P_r^{\sigma-1} Y_r \\
&= \alpha p_i^{-(\sigma-1)} \sum_r \tau_{ir}^{-(\sigma-1)} P_r^{\sigma-1} Y_r
\end{aligned}$$

Market structure in the downstream goods sector is assumed to be perfect competition. The downstream goods producer of each country combines a composite index aggregated across varieties of intermediate inputs and primary factors such as skilled and unskilled labor using a Cobb-Douglas model. This index enters the cost function for each producer through a CES aggregator. Specifically, the following cost function emerges:

$$C(X_r) = w_r^{1-\mu} G_r^\mu X_r, \quad G_r = \left[ \sum_{s=1}^R \int_0^{M_s} t_{sr}^{-(\delta-1)} q_s(j)^{-(\delta-1)} dj \right]^{-\frac{1}{\delta-1}},$$

where  $w_r$  denotes the price index for primary factors employed in country  $r$  to produce downstream output  $X_r$  (called simply wages).  $G_r$  is the price index for upstream products, and  $\mu$  is a linkage parameter between downstream and upstream goods. Unlike downstream goods, upstream products are differentiated by firm. Their market structure is assumed to be monopolistic competition. Transactions between countries  $r$  and  $s$  in upstream products are modeled as facing Samuelsonian iceberg costs,  $t_{sr} (\geq 1)$ .  $M_r$ ,  $q_r(j)$ , and  $\delta$  are respectively the number (mass) of upstream varieties produced in country  $r$ , the price of  $j$ -th variety produced in country  $r$ , and the elasticity of substitution between upstream varieties. Elasticity is again assumed to be greater than unity.

In this setting, country  $r$ 's demand for an upstream variety  $j$  produced in country  $s$  ( $z_{sr}(j)$ ) can be derived. First, applying Shephard's lemma to the above defined cost function yields:

$$H_r = \mu w_r^{1-\mu} G_r^{\mu-1} X_r, \quad \text{where } H_r = \left( \sum_s \int z_{sr}(j)^{\frac{\delta-1}{\delta}} dj \right)^{\frac{\delta}{\delta-1}}.$$

This is a country  $r$ 's composite index of consumption of upstream products. Applying the marginal cost-pricing rule to downstream products results in the following:

$$p_r = w_r^{1-\mu} G_r^\mu. \quad (2)$$

The composite index can be simplified as:

$$H_r = \mu G_r^{-1} E_r.$$



Second, since each upstream product needs to be chosen to minimize the cost of attaining  $Q_r$ , the following minimization problem is solved:

$$\min \sum_s \int t_{sr} q_s(j) z_{sr}(j) dj \quad \text{subject to} \quad \left( \sum_s \int z_{sr}(j)^{\frac{\delta-1}{\delta}} dj \right)^{\frac{\delta}{\delta-1}} = H_r.$$

With the assumption that all varieties produced in a particular country have the same technology and price, that the following can be derived:

$$z_{sr} = t_{sr}^{-(\delta-1)} q_s^{-\delta} G_r^{\delta-1} H_r.$$

Finally, substituting the simplified composite index yields the following:

$$z_{sr} = \mu t_{sr}^{-(\delta-1)} q_s^{-\delta} G_r^{\delta-2} E_r.$$

Hence, total exports of country  $s$  to country  $r$  are given by:

$$Z_{sr} \equiv M_s q_s z_{sr} = \mu M_s t_{sr}^{-(\delta-1)} q_s^{-(\delta-1)} G_r^{\delta-2} E_r. \quad (3)$$

This can be further solved as follows:

$$\begin{aligned} Z_{sr} &= \mu M_s t_{sr}^{-(\delta-1)} q_s^{-(\delta-1)} G_r^{\delta-2} \left( \alpha p_r^{-(\sigma-1)} \sum_i \tau_{ir}^{-(\sigma-1)} P_i^{\sigma-1} Y_i \right) \\ &= \mu \alpha^{-(\delta-1)} \left( M_s q_s^{-(\delta-1)} \right) \left[ G_r^{\delta-2} p_r^{-(\sigma-1)} \left( \sum_i \tau_{ir}^{-(\sigma-1)} P_i^{\sigma-1} Y_i \right) \right]. \end{aligned}$$

Taking its log, the gravity-like equation can be expressed as:

$$\begin{aligned} \ln Z_{sr} &= \ln(\mu \alpha) - (\delta-1) \ln t_{sr} + \ln M_s - (\delta-1) \ln q_s - (\sigma-1) \ln p_r \\ &\quad + (\delta-2) \ln G_r + \ln \left( \sum_i \tau_{ir}^{-(\sigma-1)} P_i^{\sigma-1} Y_i \right). \end{aligned}$$

It is assumed that upstream producers use only primary factors for production<sup>3</sup>. Hence, downstream product prices are:

$$q_s = [\delta/(\delta-1)] v_s,$$

where  $v_s$  denotes the price index for primary factors employed in a given upstream industry. Substituting these prices into the above gravity-like equation,

$$\begin{aligned} \ln Z_{sr} &= \ln[\mu \alpha \delta / (\delta-1)] - (\delta-1) \ln t_{sr} + \ln M_s - (\delta-1) \ln v_s \\ &\quad - (\sigma-1)(1-\mu) \ln w_r + \{\delta-2-(\sigma+1)\mu\} \ln G_r + \ln \left( \sum_i \tau_{ir}^{-(\sigma-1)} P_i^{\sigma-1} Y_i \right). \end{aligned}$$

For estimation, the number of upstream firms may be replaced with the total production values of upstream products using the relationship that  $M_s = Z_s / q_s z$ , where  $z$  and  $Z_s$  are respectively output per firm and total production. As a result, the estimated

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<sup>3</sup> The cost function is assumed to be homothetic in factor prices, and the marginal input requirement parameter is set to unity.

equation can be given as:

$$\ln Z_{sr} = \ln[\mu\alpha\delta/z(\delta-1)] - (\delta-1)\ln t_{sr} + \ln Z_s - \delta \ln v_s - (\sigma-1)(1-\mu)\ln w_r + \{\delta-2-(\sigma+1)\mu\}\ln G_r + \ln\left(\sum_i \tau_{ir}^{-(\sigma-1)} P_i^{\sigma-1} Y_i\right) \quad (4)$$

For the estimation of this equation, we add a stochastic error term.

Using the same notation, a traditional equation for trade in upstream products would be expressed as:

$$\ln Z_{sr} = \ln k + \beta_1 \ln Y_s + \beta_2 \ln Y_r - \beta_3 \ln t_{sr},$$

where  $k$  is a constant. Equation (4) differs from this traditional gravity equation in several ways: (i) It incorporates not only exporter upstream production scales ( $Z_s$ ) for which  $Y_s$  is usually a proxy but also wages in the upstream industry ( $v_s$ ). (ii) In addition to the price index for upstream products ( $G_r$ ) which is a common variable in the new economic geography model, equation (4) includes importer wages in the downstream industry ( $w_r$ ). This is due to the fact that countries with lower wages in downstream industries can export more downstream goods and thus import more upstream products for the production of such downstream goods. (iii) The last term of the LHS in (4) includes not only importer  $Y_r$  but also  $Y$  of other countries. This term is well-known in the NEG model as “market access”. Further, even with a log version of equation (3), the estimation of equation (4) has the advantage that it can investigate how the rise of total income in a country affects intermediate goods trade in each country (taking the role of trade costs into account). In short, equation (4) captures the important mechanics of intermediate goods trade.

### 3. Estimation Strategy

Industries must be carefully chosen to obtain data that allow for differentiation of downstream and upstream sectors. Thus, focus is placed on the motor vehicle industry. Harmonized system (HS) codes are separately available for both downstream and upstream sectors (Ando and Kimura, 2005). Using codes drawn from the UN Comtrade, bilateral trade in automobiles can be classified into both upstream and downstream sectors. The SITC 4-digit code in Revision 3 identifies downstream (3410) and upstream sectors (3420 and 3430) separately. Thus, motor vehicle production and wages in downstream and upstream sectors can be obtained separately from the UNIDO database. In order to acquire all these data in multiple years, the sample used in this research is limited to 19 OECD countries (see Appendix). Sample years were 1997, 1998, and 1999.

Trade costs  $t_{sr}$  are formalized as follows:

$$\ln t_{sr} = \rho_0 + \rho_1 \ln \text{Dist}_{sr} + \rho_2 \text{Language}_{sr} + \rho_3 \text{NAFTA}_{sr},$$

where  $\text{Dist}_{sr}$  is the geographical distance between countries  $s$  and  $r$ .<sup>4</sup>  $\text{Language}_{sr}$  is an indicator variable taking unity if a given language is spoken by at least 9% of the population in both countries; otherwise it takes the value of zero. Data for these variables comes from the CEPII website.  $\text{NAFTA}_{sr}$  is an indicator variable with a value of unity if both countries are NAFTA members.<sup>5</sup>

Obtaining the remaining two terms in RHS is known to be difficult. Feenstra (2002) has proposed that the simplest way to control the term  $G_r$  is to introduce fixed effects. Since this term differs by importer by year, importer-year dummy variables are incorporated into the present model. However, in introducing such variables, the last term in the RHS (market access) must be dropped. Since this is of major interest, the Redding and Venables method is instead applied to the trade equation for downstream goods.

Taking the log of (1), the trade equation can be rewritten as:

$$\ln X_{sr} = \ln \alpha - (\sigma - 1) \ln \tau_{sr} - \sigma \ln p_s + (\sigma - 1) \ln P_r + \ln Y_r.$$

Trade costs  $\tau_{sr}$  are again formalized as follows:

$$\ln \tau_{sr} = \phi_0 + \phi_1 \ln \text{Dist}_{sr} + \phi_2 \text{Language}_{sr} + \phi_3 \text{NAFTA}_{sr}.$$

Capturing exporter and importer characteristics by exporter ( $\text{EXP}_s$ ) and importer ( $\text{IMP}_r$ ) dummies, the estimated trade equation for downstream goods becomes:

$$\begin{aligned} \ln X_{sr} &= [\ln \alpha - (\sigma - 1)\phi_0] - (\sigma - 1)\phi_1 \ln \text{Dist}_{sr} - (\sigma - 1)\phi_2 \text{Language}_{sr} \\ &\quad - (\sigma - 1)\phi_3 \text{NAFTA}_{sr} + \eta_s \text{EXP}_s + \lambda_r \text{IMP}_r + u_{sr} \\ &= \psi_0 + \psi_1 \ln \text{Dist}_{sr} + \psi_2 \text{Language}_{sr} + \psi_3 \text{NAFTA}_{sr} + \eta_s \text{EXP}_s + \lambda_r \text{IMP}_r + u_{sr} \end{aligned}$$

$u_{sr}$  is stochastic error. Since panel data is used, actual dummies included are those of importer and exporter year. As a result,

$$\begin{aligned} \hat{\eta}_s &= -\sigma \ln p_s = -\sigma(\mu \ln w_s + (1 - \mu) \ln G_s) \\ \hat{\lambda}_r &= (\sigma - 1) \ln P_r + \ln Y_r \end{aligned}$$

Equation (2) may be used in the calculation of  $\eta_s$ . Thus, the price index ( $G_r$ ) and the market access term ( $\text{MA}_r$ ) may be expressed as:

<sup>4</sup> This is the geographical distance between the most important cities/agglomerations (in terms of population).

<sup>5</sup> An EU member dummy is not introduced because it is highly correlated with distance.

$$\ln G_r = -\left(\frac{\sigma}{\mu}\right)\hat{\eta}_r - \left(\frac{1-\mu}{\mu}\right)\ln w_r$$

$$\ln MA_r = \ln\left(\sum_i \tau_{ir}^{-(\sigma-1)} P_i^{\sigma-1} Y_i\right) = \ln \sum_i \left( Dist_{ir}^{\hat{\psi}_1} \exp(Language_{ir})^{\hat{\psi}_2} \exp(NAFTA_{ir})^{\hat{\psi}_3} \exp(\hat{\lambda}_i) \right)$$

Unfortunately, it is necessary to obtain parameter values  $\sigma$  and  $\mu$  for the calculation of  $G_r$ . These were obtained externally from Hummels (1999). Hummels provides estimates by industry at the SITC3 2-digit level. However, they are not available separately for the automobile downstream and upstream sectors. Thus, assuming identical elasticity between those sectors, 7.11 is used as an estimate of  $\sigma$ . The estimate of  $\mu$  (0.25) is calculated directly by using the US Input-Output Table for 1997 compiled by OECD<sup>6</sup>. Using these estimates, the price index  $G_r$  could be calculated.  $MA_r$ , on the other hand, can be calculated using only estimates obtained in this paper.

Particularly in the trade cost function, trade costs for the case where  $i = j$  must be treated in an exceptional manner. First,  $Dist_{ii}$  may be set to  $0.66 \cdot (\text{surface area}_i / \pi)^{1/2}$  as found in the literature of home bias measurement (see for example Head and Mayer, 2000). Second, both  $Language_{ii}$  and  $NAFTA_{ii}$  may be set to zero. Sensitivity checks of these treatments in the estimates of  $MA_r$  are reported in Section 4.3. As a result,  $MA_r$  may be decomposed into domestic ( $DMA_r$ ) and foreign ( $FMA_r$ ) market access as follows:

$$\ln MA_r = \ln(DMA_r + FMA_r),$$

where

$$\begin{aligned} DMA_r &= Dist_{rr}^{\hat{\psi}_1} \exp(\hat{\lambda}_r), \\ FMA_r &= \sum_{i \neq r} \left( Dist_{ir}^{\hat{\psi}_1} \exp(Language_{ir})^{\hat{\psi}_2} \exp(NAFTA_{ir})^{\hat{\psi}_3} \exp(\hat{\lambda}_i) \right). \end{aligned} \quad (3)$$

These measures are a baseline and are called “DMA(1)” and “MA(1)”.

Two possible econometric issues are worth noting: First, there may be a simultaneity problem between bilateral trade values ( $Z_{sr}$ ) and total production value ( $Z_s$ ). If OLS estimation is conducted for equation (4), a correlation emerges between the production value and the error term. In order to address this problem simply,  $\ln Z_s$  may be moved to the left side, avoiding reliance on instruments. Thus, the dependent variable is replaced with  $\ln (Z_{sr}/Z_s)$ . Second, there is a generated regressor problem, as noted by Pagan (1984), since values for  $G_r$  and  $MA_r$  in the gravity equation for intermediate goods trade are computed using predicted values for  $\psi$  and  $\lambda$ . In this paper, a bootstrap method is employed, and standard errors based on 200 bootstrap

<sup>6</sup> [http://www.oecd.org/document/26/0,3343,en\\_2649\\_34445\\_38069722\\_1\\_1\\_1\\_1,00.html](http://www.oecd.org/document/26/0,3343,en_2649_34445_38069722_1_1_1_1,00.html)

replications are reported.

## 4. Empirical Results

This section includes results of regression analysis. After providing the first step results (the regression results of gravity equation for finished goods trade), second step results (the regression results of gravity equation for intermediate goods trade) are reported. Several robustness checks are then provided.

### 4.1. Gravity for Finished Goods

Results of gravity estimation for finished goods trade are presented in Table 1. In this estimation, there are a number of observations with zero-valued trade. Thus, the value one has been added to all trade before taking logarithms. Column (I) shows results using an ordinary least squares (OLS) method. This provides estimates of coefficients for importer dummy variables and for coefficients in the trade cost function. Dist and Language are estimated to be significant with expected signs. The coefficient for the NAFTA dummy is significantly positive. This indicates that free trade agreements significantly increase finished goods trade among member countries. This model succeeds in explaining 98% of bilateral trade in finished goods. Before moving to the next step, the sensitivity of treatment for zero-valued trade in the results is checked. The gravity equation is estimated using a Tobit estimation technique. This result is reported in column (II) of Table 1 and is both qualitatively and quantitatively unchanged relative to the OLS result in column (I). Thus, OLS estimates are used as the basis for the next step.

=== Table 1 ===

### 4.2. Gravity for Intermediate Goods

$MA_r$  is calculated using (3) and the OLS result from Section 4.1. Mean values of country  $r$ 's imports of intermediate goods during 1997-1999 are plotted against the means of calculated  $MA_r$ , in Figure 1. Three-letter codes (see Appendix) are used to indicate each country. Excluding two outliers (Canada and Mexico), there is a clear positive relationship between a given country's access to the finished goods market and its imports of intermediate goods. Eliminating the two outliers, an approximated straight line drawn on the sample has a slope of 1.03, and this is close to the theoretical

prediction of unity. The extraordinary high market access of outliers is reconsidered in Section 4.3.

=== Figure 1 ===

Substituting predicted values of  $MA_r$  into equation (4), the gravity equation for intermediate goods may be estimated. Unlike trade in downstream goods, there are few observations in the sample (only two) with zero-value trade in upstream products. Thus, after adding the value one to all intermediate goods trade before taking logarithms, only OLS results are reported in column (I) in Table 2.

Estimates of coefficients for importer market access to finished goods market and exporter production of intermediate goods are significantly positive. Thus, imports of intermediate goods appear sensitive not only to the magnitude of importer demand for finished goods but also to demand of neighboring countries. The coefficient for exporter production of intermediate goods is near unity; this is also consistent with theoretical prediction. Estimated coefficients in the trade cost function are significant with the expected sign. As usual in studies of gravity, short distance and common language between trading partners increase trade in intermediate goods. NAFTA also contributes to expanding the trade among member countries. As expected, the estimated coefficient for importer wages is significantly negative<sup>7</sup>, but the estimation for exporter wages is significantly positive. This unexpected result may be due to the fact that wages also capture worker quality. Since intermediate goods production seems to require workers to be more highly educated than those in finished goods production, the coefficient for exporter wages might be estimated to be positive. Last, the coefficient for price index is significantly negative. Theoretically, this result implies that the elasticity of substitution may be small in intermediate goods or large in finished goods, or that a share of total expenditure on automobiles is large.

=== Table 2 ===

In order to address the above-mentioned simultaneity problem,  $\ln Z_s$  may be moved to the left side of the equation. The result is reported in column (II) of Table 2

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<sup>7</sup> However, its magnitude is significantly different from that based on the presumption that  $\sigma = 7.11$  and  $\mu = 0.25$  which were used in the calculation of the price index  $G$ . This may be due to the quality of wage data rather than econometric problems. Indeed, the estimated coefficient for wages usually has an unexpected sign. For example, Head and Mayer (2004) obtained the “wrong” sign in their location choice analysis.

and is virtually unchanged relative to (I). These results indicate that the simultaneity problem between trade and production is not so serious. Specifically, the estimated coefficient for MA is significantly positive.

### 4.3. Modifying DMA

Figure 1 shows that estimates of MAs in Canada and Mexico are extraordinarily large. It seems unnatural that these would be larger than MA in the US. Thus, calculation of MA focusing on these three countries is modified.

The first modification involves balancing DMA and FMA. The mean values of MA(1) and DMA(1) during the sample period are reported in column (I) in Table 3. It is natural that DMA in the US would be larger than that in Canada and Mexico. However, the average DMA is evaluated much lower than FMA. Such a low evaluation could be one source of extraordinarily large MAs in Canada and Mexico. The low evaluation may also be partly attributed to taking the commonality of language into account only in inter-national trade costs despite the fact that the same language is spoken within a nation. Based on this, intra-national trade costs and the method of calculating DMA may be modified as follows:

$$DMA_r(2) = Dist_{rr}^{\hat{\psi}_1} \exp(Language_{rr})^{\hat{\psi}_2} \exp(\hat{\lambda}_r) = Dist_{rr}^{\hat{\psi}_1} \exp(1)^{\hat{\psi}_2} \exp(\hat{\lambda}_r).$$

The modified DMA(2) is reported in column (II) of Table 3. Compared with the DMA(1), the modified version of DMA increases. However, MA(1) is much larger in Canada and Mexico than in the US because DMA(1) in average is still much lower than FMA.

==== Table 3 ====

Further investigation reveals that there are two sources for such low values of DMA(2). One is the evaluation of intra-national distance. Under the definition that  $Dist_{rr} = 0.66 * (\text{surface area}_i / \pi)^{1/2}$ , intra-national distance in the US (around 1,000 km) becomes larger than inter-national distance between the US and Canada (around 500 km). Obviously, it is unnatural that Canadian producers get better access to US demand for finished goods than US producers. Thus, as in Redding and Venables (2004), intra-national distance may be set to 100 km in any country. DMA may then be calculated as follows:

$$DMA_r(3) = Dist_{rr}^{\hat{\psi}_1} \exp(Language_{rr})^{\hat{\psi}_2} \exp(\hat{\lambda}_r) = (100)^{\hat{\psi}_1} \exp(1)^{\hat{\psi}_2} \exp(\hat{\lambda}_r)$$

Column (III) in Table 3 reports results of DMA(3) and shows a large increase in the US. As a result, US MA(3) reaches a similar level to that of Mexico but still much lower than that of Canada.

Another source for lower DMA than FMA is that Canada still gets better access to US markets than the US because of benefits from NAFTA. Thus, the last modification incorporates NAFTA effects into intra-national trade costs. FTAs are one means of moving member countries to an integrated or borderless economy. In this sense, the benefits of intra-national trade should be *at least* as large as the benefits of trade among FTA members. Therefore, the last modification of the calculation of DMA(4) is as follows.

$$\begin{aligned} DMA_r(4) &= Dist_{rr}^{\psi_1} \exp(Language_{rr})^{\psi_2} \exp(NAFTA_{rr})^{\psi_3} \exp(\hat{\lambda}_r) \\ &= (100)^{\psi_1} \exp(1)^{\psi_2} \exp(1)^{\psi_3} \exp(\hat{\lambda}_r) \end{aligned}$$

$NAFTA_{rr}=1$  for any country  $r$ . The results are provided in column (IV). The relationship between  $MA_r(4)$  and intermediate goods imports may also be seen in Figure 2. As a result, US  $MA(4)$  exceeds both Mexican  $MA(4)$  and Canadian  $MA(4)$  due to the remarkable rise of  $DMA(4)$ .

=== Figure 2 ===

Using these three measures of DMA, equation (4) may again be estimated. Regression results are reported in Table 4 and are almost unchanged from those in Table 2. It is interesting that both R-square and the coefficient of MA rise gradually. Since the theoretically predicted magnitude of the MA coefficient is unity, its rise implies that the measure of MA is quite valid. However, the coefficient for the best measure of MA ( $MA(4)$ ) is still far from unity (around 0.36). Thus, a more sophisticated measure of MA is needed, especially in the treatment of the intra-national trade cost function.

=== Table 4 ===

#### 4.4. Simulation

Using the model developed earlier, we simulate the impact of finished goods market expansion in a country on intermediate goods trade through input-output relationships between those two types of goods. The simulation scenario includes the rise of US final demand ( $\lambda_{US}$ , in 1999) by 10%. This increases finished goods exports



of each country to the US immediately. To produce such finished goods in a given country, it must import intermediate goods from the world. As a result, world trade in intermediate goods experiences an explosive increase. For simulation, the impact of finished goods market expansion in the US on intermediate goods trade is quantified using the case of  $\ln Z_{sr}$  in column (III) in Table 4. Specifically, differences in predicted values in the original case and the above-mentioned scenario are calculated.

Results are reported in Table 5. First, the rise of  $\lambda_{US}$  directly increases market access in each country. Obviously, such increase becomes more significant in countries that have lower trade costs with the US. Except for the US, Canada experiences the most remarkable increase in MA with Mexico following. Second, though only the US market has expansion, an increase of intermediate goods imports can be observed in all countries. This is a consequence of the model with input-output relationships.<sup>8</sup> In addition, countries with larger increases in MA import more intermediate goods. The larger increase in Canadian imports over US imports is due to the great number of imports of intermediate goods from the US. Third, exports increase in all countries. It is interesting that Japan, Germany, and the U.K. record a relatively large increase in exports due to the volume effect. Since these countries originally have a large amount of exports, changes in the *level* of exports become dramatic.

==== Table 5 ====

#### 4.5. Further Robustness Checks

Further estimations may be made using DMA and FMA as separate terms. Theoretically, this regression is not specified well, but it may be still valuable for examining the validity and significance of importer demand (DMA) and demand of neighboring countries (FMA) separately. Results are reported in column (I) in Table 6. Estimated coefficients for both DMA and FMA are significantly positive, and this indicates a significant role that demand has in neighboring countries of the importer in intermediate goods trade. The magnitude of the estimated coefficient is also a little larger in DMA than in FMA.

==== Table 6 ====

More control variables may also be added. Heretofore, only wages were

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<sup>8</sup> This is also based on a property of the CES production function and thus is a different force from the “magnification effect” found in Yi (2003).

introduced as a proxy for primary production factor prices. In order to control the effects of other primary factors, logs of importer and exporter energy production (Ex\_Energy, Im\_Energy; kilo ton of oil equivalents) and a share of R&D expenditures in GDP (Ex\_R&D, Im\_R&D) are added. Their data came from the World Development Indicator (World Bank). Results are reported in column (II) of Table 6. The coefficient for Price is insignificant, but the coefficient of MA(4) is still significantly positive though with reduced magnitude. Results in the newly-added variables were disappointing.

Finally, sample countries are extended in the estimation of the gravity equation for finished goods trade. Although the sample in the gravity equation for intermediate goods was restricted to OECD countries due to availability of data, it is important to incorporate demand emanating from non-OECD countries in the calculation of the market access measure. For example, the present measure in Japan does not incorporate access to Chinese demand, and this is one of the most important markets for Japanese finished goods producers. Thus, not only OECD countries but also non-OECD countries are included in the sample for first stage estimation (sample countries increase from 19 to 49).<sup>9</sup>

Results with this extended sample are as follows:<sup>10</sup> Column (V) in Table 3 shows calculated MA, DMA, and FMA. Figure 3 depicts the relationship of MA with imports of intermediate goods. This table and figure shows that US MA again exceeds both Mexican and Canadian MA. But new estimates in the first step-gravity equation with the extended sample yield a lower MA in most countries than before. Gravity results in intermediate goods trade are reported in column (III) of Table 6. While coefficients for importer wages and price index turn out to be positive, estimates of MA are again significantly positive, and magnitudes are larger when compared with those in Table 4. The latter result may indicate the importance of incorporating the demand of as many countries as possible in the calculation of the market access measure.

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<sup>9</sup> The following countries were added: Argentina, Bulgaria, Brazil, Switzerland, Chile, China, Colombia, Costa Rica, Cyprus, Estonia, Greece, Guatemala, Hong Kong, Croatia, India, Ireland, Iran, Israel, Kenya, Lebanon, Lithuania, Malta, New Zealand, Poland, Romania, Russian Federation, Singapore, Slovenia, Uruguay, and Vietnam.

<sup>10</sup> As in Table 1, OLS regression in the first stage yielded significant coefficients for Dist (-2.44), Language (1.74), and NAFTA (1.44).

## **5. Concluding Remarks**

The role of importer access to the finished goods market in intermediate goods trade was examined by estimating the gravity-like equation derived from the NEG model. Importer access to demand for finished goods was calculated by using the estimates in the gravity equation for finished goods trade, and then intermediate goods trade was regressed on the importer access. Results indicate that imports of intermediate goods are sensitive not only to the magnitude of importer demand for finished goods but also to the demand of neighboring countries. Using results of the regression, the impact of US finished goods market expansion on intermediate goods trade in each country was simulated. This shows that in spite of expansion of only the US market, an increase in intermediate goods imports can be observed in all countries, particularly in countries that have lower trade costs with the US.

## Appendix. Sample Country

3-letter	Country Name
AUS	Australia
AUT	Austria
CAN	Canada
FIN	Finland
FRA	France
DEU	Germany
HUN	Hungary
ITA	Italy
JPN	Japan
KOR	Korea, Republic of
MEX	Mexico
NLD	Netherlands
NOR	Norway
PRT	Portugal
ESP	Spain
SWE	Sweden
TUR	Turkey
GBR	United Kingdom
USA	United States of America

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Table 1. Gravity Estimation for Finished Goods Trade

	OLS	Tobit
Dist	-1.087*** [0.139]	-1.095*** [0.135]
Language	1.388*** [0.302]	1.408*** [0.329]
NAFTA	4.385*** [0.678]	4.385*** [0.733]
Importer*Year	YES	YES
Exporter*Year	YES	YES
Obs.	1,026	1,026
R-sq	0.9818	
Log Likelihood		-2348

*Notes:* \*\*\*, \*\* and \* indicate respectively 1%, 5% and 10% levels of statistical significance. Standard errors are shown in square parentheses. In the sample, 29 observations are left-censored at zero; 997 are uncensored.

Table 2. Gravity Estimation for Intermediate Goods Trade

	(I)	(II)
	$\ln Z_{sr}$	$\ln (Z_{sr}/Z_s)$
Dist	-1.135*** [0.047]	-1.155*** [0.047]
Language	0.871*** [0.169]	0.826*** [0.170]
NAFTA	2.364*** [0.390]	2.269*** [0.392]
Output ( $Z_s$ )	0.927*** [0.039]	
Wages ( $w_r$ )	-0.624*** [0.181]	-0.633*** [0.181]
Wages ( $v_s$ )	0.383*** [0.118]	0.293*** [0.095]
Price ( $G_r$ )	-0.417*** [0.035]	-0.420*** [0.035]
MA(1)	0.098*** [0.034]	0.103*** [0.034]
Year	YES	YES
Obs.	1,026	1,026
R-sq	0.6688	0.5314

Notes: MA(1) was calculated by making intra-national trade costs a function only of intra-national distance, defined as  $0.66 * (\text{surface area}_i / \pi)^{1/2}$ . \*\*\*, \*\* and \* indicate respectively 1%, 5% and 10% levels of statistical significance. Bootstrapped standard errors are in parentheses (200 replications).



Table 3. Mean Market Access during Sample Period

	OECD Sample								Extended Sample			
	(I)			(II)		(III)		(IV)		(V)		
	ln FMA	ln MA(1)	ln DMA(1)	ln MA(2)	ln DMA(2)	ln MA(3)	ln DMA(3)	ln MA(4)	ln DMA(4)	ln MA(4)	ln DMA(4)	ln FMA
AUS	15.7	16.0	14.6	16.5	15.9	18.6	18.5	22.9	22.9	23.1	23.1	12.2
AUT	18.5	18.7	16.7	19.0	18.0	19.1	18.1	22.5	22.5	20.2	20.1	18.5
CAN	22.7	22.7	13.0	22.7	14.4	22.7	17.1	23.0	21.5	21.5	21.3	19.7
DEU	18.0	18.8	18.2	19.8	19.6	20.5	20.5	24.9	24.9	24.7	24.7	18.7
ESP	17.4	17.7	16.3	18.3	17.7	19.0	18.8	23.2	23.2	22.3	22.3	16.2
FIN	17.2	17.4	15.5	17.7	16.8	18.2	17.7	22.1	22.1	19.5	19.5	16.6
FRA	18.2	18.4	16.7	18.9	18.1	19.5	19.2	23.6	23.6	22.4	22.3	18.9
GBR	18.1	18.6	17.5	19.3	18.9	19.8	19.6	24.0	24.0	24.3	24.3	18.1
HUN	17.7	17.7	14.4	17.8	15.8	17.9	15.9	20.4	20.3	19.2	19.1	17.0
ITA	17.3	18.0	17.3	18.9	18.7	19.6	19.5	23.9	23.9	24.1	24.1	16.4
JPN	15.5	17.6	17.4	18.9	18.8	19.7	19.7	24.1	24.1	23.0	23.0	11.9
KOR	16.7	16.7	12.6	16.8	14.0	16.9	14.2	18.9	18.6	18.7	18.6	14.2
MEX	20.7	20.7	11.5	20.7	12.9	20.7	14.7	20.9	19.1	20.6	20.6	15.3
NLD	18.8	19.1	17.5	19.6	18.9	19.4	18.7	23.1	23.0	22.8	22.7	20.3
NOR	17.5	17.6	15.3	17.9	16.7	18.2	17.5	21.9	21.9	20.0	19.9	17.0
PRT	17.2	17.5	15.9	18.0	17.3	18.0	17.4	21.8	21.8	20.5	20.4	16.0
SWE	17.4	17.6	15.5	17.9	16.9	18.4	17.9	22.3	22.3	22.5	22.5	16.3
TUR	17.0	17.0	14.1	17.2	15.5	17.6	16.8	21.2	21.2	19.6	19.6	15.5
USA	19.7	19.7	16.1	19.8	17.5	20.7	20.2	24.6	24.5	23.8	23.8	17.2

Notes: DMA(1) are calculated by setting intra-national trade costs as a function of only intra-national distance (defined as  $0.66 * (\text{surface area}_i / \pi)^{1/2}$ ).

DMA(2) are calculated using a function of not only the intra-national distance (as in (I)) but also  $\text{Language}_{ii}$ , (further set to unity). DMA(3) are calculated using a function of intra-national distance (set to 100km in any country), and  $\text{Language}_{ii}$ , (set to unity). In DMA(4), intra-national trade costs are assumed to be a function of intra-national distance (set to be 100km in any country),  $\text{Language}_{ii}$ , and  $\text{NAFTA}_{ii}$ , (both set to unity).

Table 4. Gravity Estimation for Intermediate Goods Modifying DMA

	(I)		(II)		(III)	
	$\ln Z_{sr}$	$\ln (Z_{sr}/Z_s)$	$\ln Z_{sr}$	$\ln (Z_{sr}/Z_s)$	$\ln Z_{sr}$	$\ln (Z_{sr}/Z_s)$
Dist	-1.133*** [0.046]	-1.154*** [0.047]	-1.171*** [0.047]	-1.188*** [0.047]	-1.089*** [0.045]	-1.112*** [0.046]
Language	0.887*** [0.169]	0.842*** [0.170]	0.828*** [0.169]	0.792*** [0.169]	0.961*** [0.161]	0.911*** [0.162]
NAFTA	2.382*** [0.388]	2.289*** [0.391]	1.940*** [0.402]	1.861*** [0.404]	2.545*** [0.340]	2.451*** [0.345]
Output ( $Z_s$ )	0.926*** [0.039]		0.942*** [0.038]		0.916*** [0.038]	
Wages ( $w_r$ )	-0.610*** [0.179]	-0.620*** [0.179]	-0.722*** [0.170]	-0.732*** [0.169]	-1.074*** [0.163]	-1.084*** [0.164]
Wages ( $v_s$ )	0.384*** [0.118]	0.293*** [0.095]	0.359*** [0.116]	0.287*** [0.093]	0.401*** [0.119]	0.299*** [0.094]
Price ( $G_r$ )	-0.407*** [0.035]	-0.409*** [0.035]	-0.382*** [0.034]	-0.383*** [0.034]	-0.375*** [0.035]	-0.378*** [0.034]
MA(2)	0.105*** [0.037]	0.109*** [0.037]				
MA(3)			0.307*** [0.041]	0.313*** [0.041]		
MA(4)					0.362*** [0.040]	0.360*** [0.040]
Year	YES	YES	YES	YES	YES	YES
Obs.	1,026	1,026	1,026	1,026	1,026	1,026
R-sq	0.6688	0.5312	0.6827	0.5516	0.6844	0.5528

Notes: MA(2) are calculated as a function not only of intra-national distance (defined as  $0.66 \cdot (\text{surface area}_i / \pi)^{1/2}$ ), but also  $\text{Language}_{ii}$  (further set to unity). MA(3) are calculated using a function of intra-national distance (set to be 100km in any country) and  $\text{Language}_{ii}$ , (set to unity). In MA(4), intra-national trade costs are assumed to be a function of intra-national distance (set to 100km in any country),  $\text{Language}_{ii}$ , and  $\text{NAFTA}_{ii}$ , (both set to unity). \*\*\*, \*\* and \* indicate respectively 1%, 5% and 10% levels of statistical significance. Bootstrapped standard errors are in parentheses (200 replications).

Table 5. Simulation: Impact of a 10% Rise in the US Market (US \$1,000)

	MA(4)	Imports	Exports
AUS	599	6	1,042
AUT	379	43	817
CAN	1,884,473	3,867,829	1,610,208
DEU	432	8	15,731
ESP	1,817	93	7,336
FIN	390	22	196
FRA	448	26	9,125
GBR	1,888	163	14,304
HUN	367	43	173
ITA	374	12	3,373
JPN	228	3	25,868
KOR	895	1,299	3,926
MEX	261,777	177,296	38,871
NLD	446	85	842
NOR	441	22	299
PRT	485	22	338
SWE	411	37	991
TUR	315	10	144
USA	11,990,024	1,700,212	4,013,647
Total	14,146,189	5,747,230	5,747,230

*Notes:* This table shows the results of the simulation of a 10% rise in the US market ( $\lambda_{US}$ ) and uses the result obtained in the case of  $\ln Z_{sr}$  in column (III) in Table 4. Changes in MA(4), total imports of intermediate goods, and exports are reported.

Table 6. Gravity Estimation for Intermediate Goods Trade: Robustness Checks

	(I)		(II)		(III)	
	$\ln Z_{sr}$	$\ln (Z_{sr}/Z_s)$	$\ln Z_{sr}$	$\ln (Z_{sr}/Z_s)$	$\ln Z_{sr}$	$\ln (Z_{sr}/Z_s)$
Dist	-1.067*** [0.047]	-1.091*** [0.048]	-1.164*** [0.045]	-1.152*** [0.045]	-1.137*** [0.042]	-1.159*** [0.043]
Language	0.892*** [0.167]	0.839*** [0.167]	0.813*** [0.162]	0.835*** [0.161]	0.847*** [0.154]	0.801*** [0.154]
NAFTA	2.452*** [0.361]	2.343*** [0.363]	2.237*** [0.373]	2.266*** [0.370]	2.540*** [0.326]	2.450*** [0.329]
Output ( $Z_s$ )	0.915*** [0.039]		1.073*** [0.039]		0.923*** [0.038]	
Wages ( $w_r$ )	-1.050*** [0.168]	-1.055*** [0.169]	-1.478*** [0.175]	-1.467*** [0.175]	0.513*** [0.099]	0.514*** [0.098]
Wages ( $v_s$ )	0.407*** [0.119]	0.303*** [0.094]	0.479*** [0.128]	0.515*** [0.122]	0.392*** [0.122]	0.297*** [0.096]
Price ( $G_r$ )	-0.397*** [0.036]	-0.401*** [0.035]	-0.444*** [0.034]	-0.439*** [0.034]	0.013 [0.016]	0.015 [0.016]
MA(4)			0.219*** [0.045]	0.223*** [0.045]	0.444*** [0.027]	0.446*** [0.027]
DMA(4)	0.259*** [0.035]	0.254*** [0.034]				
FMA(4)	0.133*** [0.029]	0.136*** [0.029]				
Im_Energy			0.392*** [0.041]	0.388*** [0.041]		
Ex_Energy			-0.306*** [0.048]	-0.273*** [0.042]		
Im_R&D			-0.123 [0.124]	-0.115 [0.125]		
Ex_R&D			0.027 [0.115]	0.053 [0.118]		
Year	YES	YES	YES	YES	YES	YES
Obs.	1,026	1,026	1,026	1,026	1,026	1,026
R-sq	0.6615	0.5204	0.7357	0.6260	0.6864	0.5559

Notes: The sample used in the first stage estimation in column (III) includes not only OECD but non-OECD countries as well. \*\*\*, \*\* and \* indicate respectively 1%, 5% and 10% levels of statistical significance. Bootstrapped standard errors are in parentheses (200 replications).

Figure 1. Intermediate Goods Imports and MA(1)

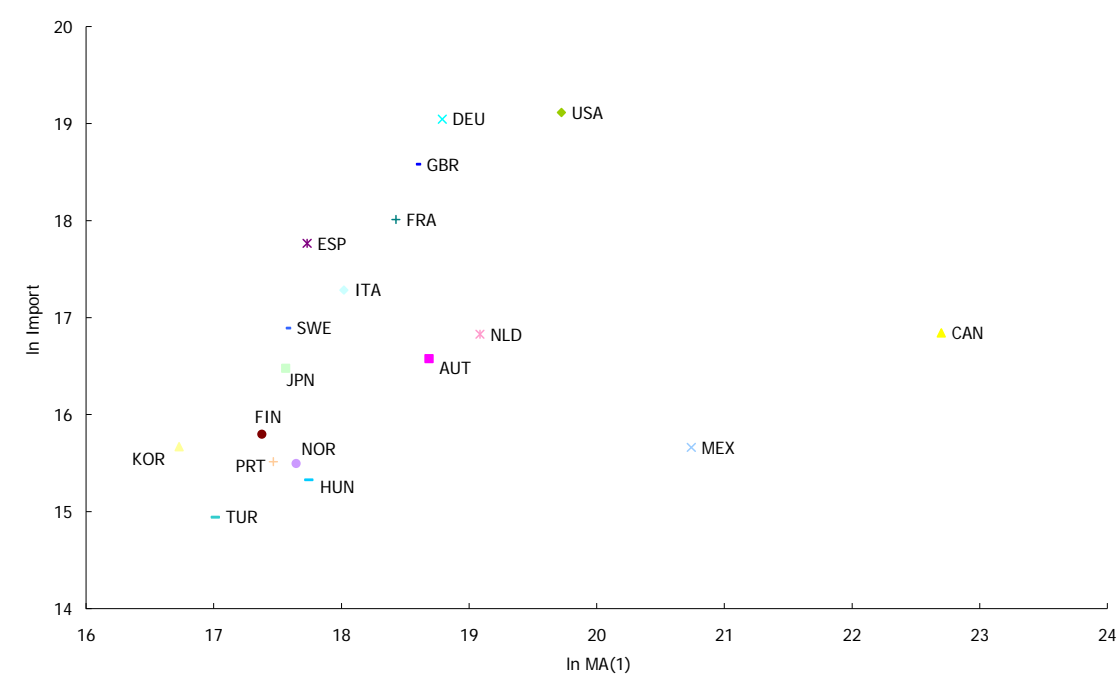


Figure 2. Intermediate Goods Imports and MA(4)

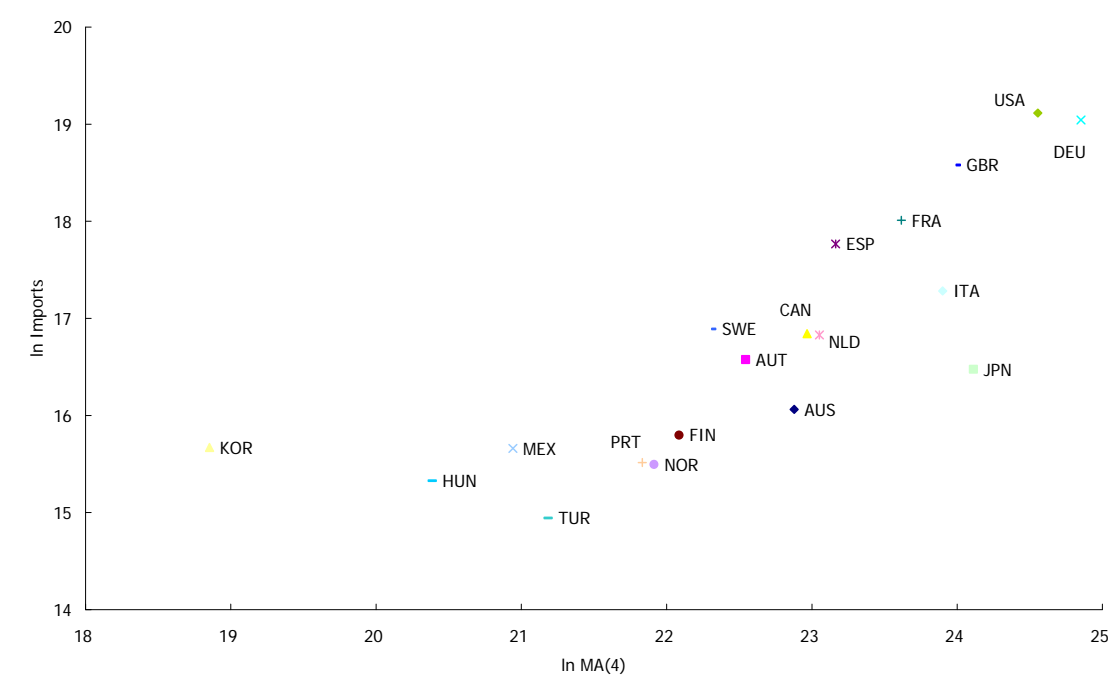
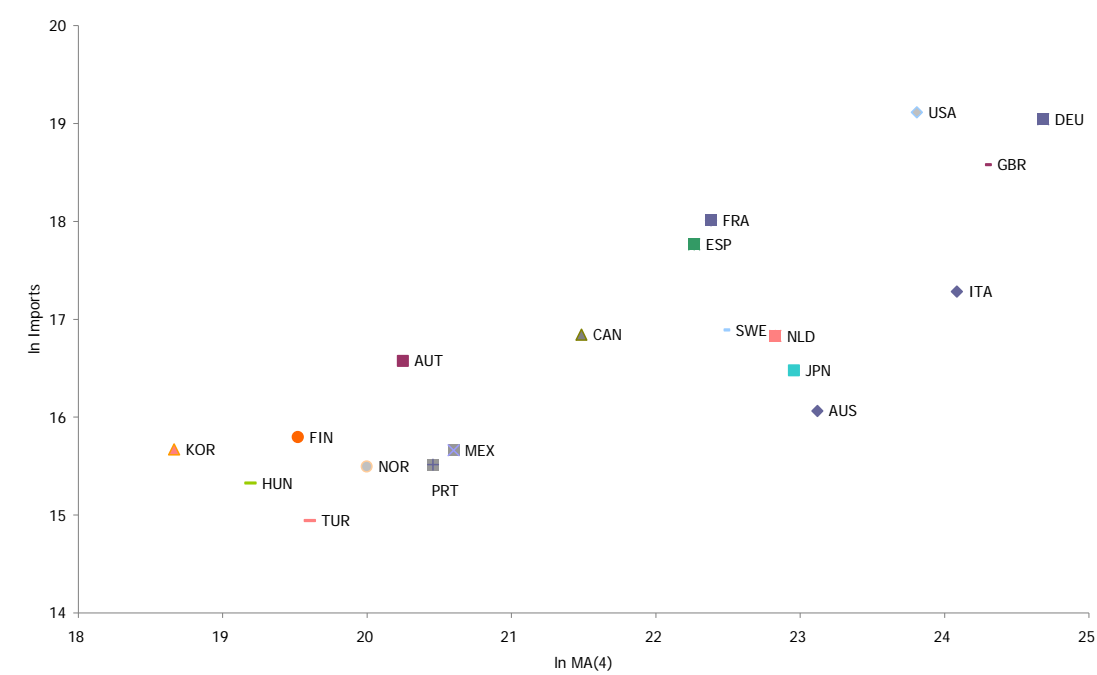


Figure 3. Intermediate Goods Imports and MA(4): Extended Sample



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